

FOREST MODELING OF JACK PINE TREES FOR BOREAS

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ABSTRACT

As part of the intensive field campaign (IFC) for the Boreal forest ecosystem-atmosphere research (BOREAS) project in August 1993, the NASA/JPL AIRSAR covered an area of about 100 km x 100 km near the Prince Albert National Park in Saskatchewan, Canada. At the same time, ground-truth measurements were made in several stands which have been selected as the primary study sites, as well as in some auxiliary sites. This paper focuses on an area including Jack Pine stands in the Nipawin area near the park. Upon examining the SAR data from stands of old and young Jack Pine (OJP and YJP) it is observed that the OJP stand produces HH backscatter at P-band which is significantly higher than that from YJP. The OJP trees are taller and have larger diameters, but are much more sparse than the YJP trees. The YJP trees, on the other hand, have denser and greener crown layer. The radar backscatter values for VV polarization and at other frequencies do not manifest such a large difference. For HV backscatter, although P-band return is again larger than C- and L-bands, the difference is not as marked. To explain this distinct signature of OJP stands, a forest scattering model is used in conjunction with the ground-truth measurements. The forest model includes the major scattering mechanisms (volume, double-bounce, and single-bounce) by taking the forest component interactions into account. The contribution from each of the scattering mechanisms to the total backscatter is calculated and their differences for OJP and YJP stands are evaluated. The results are used to discuss the effect of the physical properties of the forest components in each stand on radar backscatter, in particular, for HH polarization at P-band.

1. INTRODUCTION

In August 1993, the NASA/JPL airborne synthetic aperture radar (AIRSAR) acquired polarimetric C-, L-, and P-band backscattering data over several sites of the boreal ecosystem atmosphere study (BOREAS) project, both in the Southern and Northern study areas. These areas included diverse forest canopies such as Aspen, young and old Jack Pines, and Black Spruce. Five locations in the south and four in the north were chosen as primary study sites, where flux towers were set up (BOREAS Experiment Plan, 1993). In this work, we focus on the SAR data obtained over an area containing primarily Jack Pine

trees. Specifically, we will consider a young Jack Pine (YJP) stand, which is one of the areas selected as a flux tower site, and a nearby old Jack Pine (OJP) stand, which is not a flux tower site, but is similar to and within a few kilometers of the tower site OJP. In conjunction with the SAR measurements, ground truth data were obtained at these areas to characterize the canopy.

From SAR data, a strong distinction between YJP and OJP backscatter are observed at P-band. In the OJP stand, the HH polarized return is much higher, up to 9 dB, than that in the YJP stand, as well as the VV return in either stand. In this paper, first some samples of SAR data at the three frequencies and for HH, VV, and HV polarizations are reported for these areas. A forest scattering model is then used, with the aid of ground truth measurements, to identify the mechanisms contributing to the above effects at P-band. The effect of incidence angle is also considered. The distinct behavior of HH and VV backscatter at P-band might thus be used as a tool for identification of OJP stands or those with similar characteristics.

2. OBSERVATIONS FROM SAR DATA

Table 1 shows some representative values from SAR data for HH and VV returns at C-, L-, and P-bands for YJP and OJP. The SAR image (not shown here) consists of 1280 lines and 1024 pixels per line. The value of backscatter at each point shown in the table (pixel-line pair) is found by averaging the corresponding values over a 5 x 5 box centered at that point. The aircraft flight parameters are such that the center of YJP stand is at 43° incidence angle and that of the OJP at 52°. Some observations from these data are:

- The OJP HH return is on the average 8 dB higher than that for YJP and at L-band and C-band.
- The HH return is on the average 8 dB higher than VV at P-band for the OJP.
- At L- and C-bands, each of the backscatter polarizations are similar in magnitude for OJP and YJP.

The result of interest for this work is that the P-band return over the OJP stand is much higher than VV and that at the YJP. In the following sections, we will look at a forest scattering model and use ground truth measurement to identify the reason for this effect.